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BUREAU OF CHEMISTRY—BULLETIN NO. 70.

H. W. WILEY, CHIEF OF BUREAU.

MANUFACTURE

OF

TABLE SIRUPS FROM SUGAR CANE.

BY

H. W. WILEY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., July 1, 1902.

Sir: I have the honor to transmit herewith the manuscript for a bulletin on the manufacture of sirups from sugar cane. This bulletin has been prepared as a result of my personal inspection of the growth of sugar cane and the manufacture of sirup therefrom in Georgia, undertaken by your special direction.

I recommend that this manuscript be published as Bulletin No. 70 of the Bureau of Chemistry.

Respectfully,

H. W. Wiley,
Chief.

Hon. James Wilson,
Secretary of Agriculture.

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MANUFACTURE OF TABLE SIRUPS FROM SUGAR CANE.

INSPECTION OF GEORGIA SUGAR-CANE FIELDS AND SIRUP FACTORIES.

Since the introduction of sugar cane into the United States over a hundred years ago its cultivation for the purpose of manufacturing table sirups has been extended until it is now practiced over large areas of southern Texas, nearly the whole of the State of Louisiana, portions of southern Mississippi and Alabama, the southern part of Georgia and South Carolina, and over the whole extent of Florida.

Nearly all of the methods which have been employed for this purpose have been of a crude nature and involve no accurate knowledge of the character of the cane employed, the amount of sugar which it contained, or the chemical composition of the product secured. Very few manufacturers have measured the land on which the cane was grown, weighed the cane produced, or determined the percentage of extraction in the mills employed or the yield per ton and acre of the sirup secured.

The quality of the product made has usually been of high character, and the appreciation of its value for the breakfast table and for cooking purposes has gradually grown until it is now a recognized food product throughout the whole of the region mentioned and in many other parts of the Union to which it has been sent. So great has become the demand for this wholesome, palatable, and nutritious article of diet that in the past few years manufacturing establishments have been erected on a much more elaborate scale and under much more rigid control than heretofore. The old-fashioned mule mill and iron kettle have given way to the steam mill and steam evaporator. Improved methods of the treatment of the juice have been practiced, and attempts have been made to secure an article of standard quality and properties. Merchants desire to handle a uniform grade of sirup, so that when its value is once established they can meet the demands of their customers for this particular kind.

One of the greatest difficulties, from a commercial point of view, with which the table sirup industry in the South has to contend is this lack of uniformity. This, coupled with the tendency of the sirup to ferment in warm weather, has restricted its markets to a rather limited area. An additional difficulty which these sirups find on the

market is the fact that our grocery stores are stocked with artificial sirups; that is, those made of mixtures of various kinds in which glucose is one of the essential ingredients. There should be no restriction of the legitimate trade in mixed articles of wholesome food, but when they are sold under names which are misleading, an injury of a serious character is done to products which are truly representative in name and character. There can be no valid objection to the sale of mixed table sirups of any kind, provided they contain no injurious ingredient, but their sale as maple, sugar-cane, or sorghum sirup manifestly works an injury to a legitimate trade in the genuine articles.

Chiefly through the representations of Capt. D. G. Purse, president of the Savannah Board of Trade, the U. S. Department of Agriculture has become interested in the development of the table-sirup industry in the South. In November, 1901, the writer made a visit to some of the principal centers of this industry to study the conditions existing and to confer with manufacturers in regard to the improvements and the investigations which the Department of Agriculture might undertake to the advantage not only of the producers but of the consumers of this important product as well. Starting from Savannah on November 18, visits were made to various points on the Central Railroad of Georgia. The morning was cold and frosty, and the cane which had been exposed was found frozen. Icicles were noticed in many localities. The excursion was conducted by the land and industrial agent of the Georgia Central Railroad.

The first visit was made to the steam factory of Mr. J. G. Wells, of Guyton, which was found well equipped and conveniently arranged for economy in handling the raw material and the finished product. The character of the cane grown by Mr. Wells is shown in Pl. I, fig. 1, representing one of the fields near the factory. The arrangement of the evaporating apparatus, which was a self-skimmer, is shown in Pl. I, fig. 2.

The ingenious arrangement of this skimming appliance secured a very pure and bright finished article, and at the same time the scums were removed without any notable loss of sirup. A general view of the factory, from which can be seen the neatness and strength of the structure, is shown in Pl. II, fig. 1.

The next locality visited was the factory of Mr. E. E. Foy, at Egypt. A general view of Mr. Foy's factory is given in Pl. II, fig. 2. Mr. Foy makes a specialty of feeding the skimmings and other waste products to pigs. The arrangement of his pigpens is shown in Pl. III, fig. 1. The well-known fattening properties of skimmings was illustrated in a striking manner by the sleek and rotund condition of the pigs being fed.

The next factory visited was that of Capt. Thomas J. James, of Adrian. Captain James had one of the most extensive cane fields

seen in Southern Georgia. A striking illustration of the luxuriant growth of the cane is given in Pl. III, fig. 2. Captain James has a large factory operated by steam.

In addition to the cane fields the plantation of Mr. J. W. Olliff, at Statesboro, was also inspected. At the time of the inspection of this region the sirup campaign was not completed in many localities, and large quantities of cane were still in the fields. An interesting question was raised at once in regard to the effect of the severe cold then prevailing on the cane itself. In most places the cane is either windrowed or cut and piled in bulk and protected by the leaves and tops. In these instances the cane was not frozen, and there was no question in regard to its preservation until the end of the manufacturing season. The cutting of the cane in this way is not injurious to the product, as would be the case if sugar making were practiced, since one difficulty which attends the sirup industry in Georgia is the tendency of the finished product to crystallize and thus decrease its value on the market. Keeping the cane windrowed or in heaps for some time after cutting will afford the opportunity for the inversion of a part of the cane sugar, thus diminishing the tendency to crystallization in the finished product without diminishing the amount of the product or impairing its quality.

On the 19th of November an inspection of the cane fields and factories in the southern part of Georgia, near the Florida line, was accomplished. In addition to Captain Purse, the party included Mr. James Menzies, general freight agent of the Plant System, Mr. C. B. Roberts, and Mr. D. F. Kirkland, superintendent of the third division of the Plant System. At Waycross the train was met by Mr. W. W. Sharpe, Mr. G. R. Youmans, and Mr. J. W. Greer, who urged that a visit be made to the cane fields near that city, but the itinerary already arranged would not allow a stop-over at that time.

At Valdosta the inspecting party was welcomed by Mr. J. G. Crawford; Mr. J. M. Wilkinson, president of the Valdosta Southern Railroad; Mr. Brantley, editor of the Valdosta Times; Mr. Will McRee, Mr. William Roberts, Col. Ben Jones, and other citizens.

At Kinderlou an inspection was made of the farm and factory of Mr. McRee. Here some of the best illustrations of the intensive culture of sugar cane were found. An excellent idea of the luxuriant character of the cane grown at Kinderlou is shown in Pl. IV, figs. 1 and 2.

A most interesting incident of the visit to Kinderlou was an inspection of one of the cassava fields on the plantation. The growth of the cassava was of the most luxuriant kind, and although the leaves had been frosted, it still presented a most attractive appearance, as is shown in Pl. V, fig. 1.

The purple variety of cane was the one chiefly grown on Mr. McRee's plantation. Some of the cut stalks already in the mill measured over 8 feet in length and weighed from 4 to 6 pounds.

Although no weighings were made of measured portions, it was evident to all familiar with cane fields and the yields which they give that the field of cane shown in Pl. IV, fig. 1, would yield from 25 to 30 tons per acre. Mr. McRee estimated that his crop would yield an average of 850 gallons of sirup per acre. He had 56 acres in cane, all of which was devoted to sirup making. The fertilizer which he used was a complete one, composed of potash, cotton-seed meal, and acid phosphate, and of this mixture the amount usually applied is from 800 to 1,000 pounds to the acre. On new land, however, the quantity of this material is correspondingly diminished.

This part of Georgia appears to be practically the center of the cane-sirup industry, and, judging by what has been accomplished by Mr. McRee, there is no limit to the extent of the industry save the capacity of the market to be supplied.

The Georgia Land and Improvement Company is said to have options on over 400,000 acres of land in Clinch County, which will be utilized for the establishment of a cattle industry and for raising cane.

At Quitman the party was taken in charge by Judge Joseph Tillman and Mr. W. A. Davis. The board of trade was visited and a large number of the citizens of Quitman were presented to the party. W. A. Davis & Co., of Quitman, sell about 3,500 barrels of sirup a year. Until a few years ago the market was restricted to Georgia, but it now extends from Massachusetts to Texas.

From Quitman the party proceeded to Cairo, where the mill of Mrs. M. L. Wight was visited. This is the largest sirup mill in this section and is a type of the best modern construction. In most of the factories visited no attempt was made to chemically clarify the juices, but dependence was placed altogether on the action of heat and skimming. At the Wight mill, however, the juices were sulphured cold, as is practiced with the cane juices used for sugar making in Louisiana, and subsequently lime was added nearly to neutrality, thus producing a good clarification without darkening the color of the finished product.

Cairo is the center of shipment for sirup in southern Georgia. About 2,500 acres are planted in cane within a radius of 15 miles from the town, and the shipment from Cairo last year amounted to 10,000 barrels of sirup. A general view of the Wight mill is shown in Pl. V, fig. 2.

Particular attention is called to the contrivance at the Wight mill, as shown in the figure, for handling the cane by machinery. In loading a wagon ropes are first laid across the wagon body, on which the canes are laid. These ropes are afterwards tied, and by means of a crane the whole load is removed at once. The factory is built on the side of a hill, so that all the handling of the materials in the factory, after the unloading of the cane by means of the crane, is by gravity, thus securing the greatest economy in manual labor.

FIG. 1.—CANE FIELD OF J. T WELLS, GUYTON, GA.

FIG. 2.—EVAPORATOR OF J. T. WELLS, GUYTON, GA.

FIG 1.—SIRUP FACTORY OF J. T. WELLS, GUYTON, GA

FIG. 2.—SIRUP FACTORY OF E. E. FOY, EGYPT, GA.

FIG. 1.—PIGPENS AT E. E. FOY'S FACTORY, EGYPT, GA.

FIG. 2.—CANE FIELD OF T. J. JAMES, ADRIAN, GA.

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FIG 1.—CANE FIELD OF WILL MCREE, KINDERLOU, GA.

FIG. 2.—CANE FROM WILL MCREE'S FIELD, KINDERLOU, GA.

From Cairo the party returned to Waycross and proceeded to Jacksonville, Fla., where the Florida Agricultural Society was addressed on the subject of cane and cassava culture in Florida. A synopsis of the address is as follows:

CANE AND CASSAVA CULTURE IN FLORIDA.

By H. W. Wiley.

The problems connected with the sugar and starch products are four or five in number.

First of all, the soil is to be considered, and therefore agricultural interests should pay some attention to staple crops—that is, crops that have a market the year round, and can be preserved and marketed at any time. Sugar and starch are types of such crops. These substances take absolutely nothing from the soil; they are fabricated by the plant from the atmosphere and water: hence the sale of such products does not tend to impoverish the soil.

The soils of Florida are largely of a sandy nature—that is, they have been deposited from water: they are typically different from the soils of the great Northwest, which were produced by the grinding effect of moving icebergs, and represent the richest soils, probably, in the world. Sandy soils are not suitable for producing wheat, for instance, but they are well adapted to producing sugar and starch. In Florida it is more a question of climate than of soil, since, with a favorable climate, scientific agriculture will produce a crop from almost any kind of soil.

The second problem to be considered is that of fertilizers. Perhaps there is no State more favorably situated than Florida in respect to fertilizers. You have here inexhaustible deposits of phosphate. In the leguminous crops which grow here, namely, peas, beans, alfalfa, and beggar-weed grass, you have a most valuable means of assimilating nitrogen from the air. In cotton seed, fish scrap, and other animal refuse you have access to large stores of nitrogen. Through your seaports stores of fertilizing materials, such as nitrate of soda and potash salts, can be brought from South America and Germany. It would be hard to find any other portion of our country where fertilizers could be sold more cheaply than in this State.

CHARACTER OF THE MARKET.

The third problem is the character of the market. This country is the greatest sugar and starch consumer in the world. We use more than 2,000,000 tons of sugar annually. Of this quantity, before the Spanish war, we made only about 300,000 tons—about one-seventh of all.

Since the Spanish war we have acquired Hawaii, Porto Rico, and the Philippines, all of which give us large additional quantities of sugar. This year we will produce about 100,000 tons of beet sugar, so that at the present time it may be said that we produce about one-third of all the sugar we consume; but still there is a vast foreign market which we might supply with the home product. There is no danger, therefore, of overstocking our home market with increased sugar production, nor is there danger of the beet sugar driving the cane sugar out of the market. For many purposes, as, for instance, the manufacture of sirup, beet sugar is unsuitable, and there will always be a demand for all the cane sugar that can be made.

The sugar crop of the whole world for the present year is about 10,000,000 tons, of which nearly 7,000,000 are made from the sugar beet.

THE SUGAR BEET.

The sugar beet can not, however, be grown in Florida profitably. Here you must depend on the sugar cane for sugar and upon the cassava and potato for starch. From starch glucose can also be made, and it seems to me that in the near future the glucose industry will pass from the indian-corn belt to the cassava and potato belt. In one particular industry Florida and the southern parts of Georgia and Alabama stand preeminent, and that is the manufacture of table sirup from sugar cane. It is important, however, to secure uniform grades to hold the markets of the world, and this can only be accomplished by mixing together the products of small farmers or by the establishment of central factories, where the cane grown in the neighborhood can be manufactured under standard conditions.

By the development of these great industries, sugar and starch making, including table sirups, untold wealth will in the near future flow into Florida. From by-products of the factories immense quantities of cattle food can be obtained, both from sugar cane and the starch-producing plants. Thus a dairy industry can be established in connection with sugar and starch making, which will add much to the wealth of the State.

From Jacksonville the party returned to Brunswick, Ga., where a banquet was given by the board of trade at the Oglethorpe Hotel, after which a reception was tendered at the Phœnix Club. The question of the development of the sugar-cane and cassava industries was informally discussed at this reception by the leading business men of Brunswick.

From Brunswick the party proceeded to Waycross, where it was met by the board of trade of that city and where samples of canes, gathered from different parts of the locality, were inspected. The magnitude of these canes is best shown by the photograph taken at Waycross, showing a number of gentlemen most interested in the industry and the size of the canes typical of the growth secured in the immediate locality. (Pl. VI, fig. 1.)

At Waycross one of the best of the small mills for making sirup was inspected, viz, the mill of Mr. Hatcher, about 1 mile southwest of the town. This mill is a small one, operated with a single mule as power, and is best illustrated by referring to Pl. VI, fig. 2.

The method of feeding the cane to this mill is shown in Pl. VII, figs. 1 and 2.

The evaporator, which is a single iron kettle set in masonry, is shown in Pl. VIII, fig. 1.

The structure of the furnace at Mr. Hatcher's mill, which is the best type of this character of furnace, is seen in Pl. VIII, fig. 2.

One of the most interesting places visited near Cairo was the thoroughly primitive establishment of Capt. E. A. Vanlandingham. It was already growing dark on our arrival, and thus an opportunity was afforded of seeing this quaint factory in its most picturesque state, viz, illuminated by a torch of "lightwood." This method of illumination is the one universally practiced in the old-fashioned establishment represented in Pl. IX.

It must be admitted that some of the best sirup which has been brought to our attention has been manufactured in the simple way illustrated in the figure. Of course, the quantities that can be made in a single kettle are limited, and there can be but little commercial importance attached to goods manufactured in this way. For the supply of the farmer himself and his neighbors, however, it is more than likely that this method of manufacture will continue to exist for a long while, and, in fact, there seems to be no necessity or desire that it should ever entirely pass away.

A similar establishment is also represented in Pl. X, which is also interesting in being the property of a colored man, William Lomax, living near Cairo, Ga. The scene is thoroughly characteristic, and represents at its best the rural life of this region when the season for sirup making is at its height.

THE SOIL.

Geologically the soils in southeastern South Carolina on which sugar cane is grown lie principally on the formations known as Lafayette and Marine Pliocene and Miocene. Agriculturally they are classed as sand soils, and the natural timber growth originally found on them was almost exclusively longleaf pine. These soils, as is well known, have a low fertility and require generous fertilization to produce paying crops.

The same soils prevail in southern and southwestern Georgia, while in Florida, without any pronounced difference in the appearance of the soils, the geological formations are chiefly Marine Miocene in the northern part of the peninsula and Marine Pliocene in the southern and interior central regions.

The Lafayette formation is composed of distinctive orange-colored sands and clays, sometimes interbedded with gravel or interspersed with pebbles. The formation is overlaid by the alluvions of small streams, by æolian sands, and in some places by wave-washed débris. The overlay is also often composed of the characteristic clays, sands, and gravels of the Columbia formation, especially in proximity to large streams. This area has also been described by the names "orange sand," "drift," "quaternary," and "southern drift."

The Lafayette formation in Georgia is overlaid for thousands of square miles with the sands of the Columbia formation, covered originally, and still to a great extent, with longleaf pines. A typical soil on the Suwanee River, between Hamilton and Columbia counties, was found to have the following formation:

	Feet.
1. Gray soil, sand, and humus	2
2. White sand	4
3. Clay with silicified corals and oyster shells	6 to 8
4. Indurated clayey rock	2

Throughout large areas in Florida and, to a less extent, in Georgia and South Carolina, in low, swampy localities, the soil has become overlaid with vegetable deposits of a humus nature. These vegetable soils are deficient in mineral plant foods, but become very fertile when properly drained and fertilized. For a more detailed geological account of the soils of the localities referred to, Bulletin No. 83 of the U. S. Geological Survey may be consulted.

A valuable contribution to the study of the soil of Georgia is also found in the Tenth Census Report, vol. 6, on the cotton production of the State of Georgia, by R. H. Loughridge. This report contains an agricultural map of Georgia, showing the distribution of the various kinds of soils in the State. A similar map for South Carolina is found in the Report of the Tenth Census, vol. 6, a report on the cotton production of South Carolina, by Harry Hammond. A similar map is also given in the same volume for the State of Florida, being a report on the cotton production of Florida, by Eugene Allen Smith. A study of these maps, with the remarks made thereon, together with the analyses of the soils which follow, will give a fair idea of the agricultural possibilities of the States mentioned.

NOTES ON THE SOILS.

In the table of analyses of soils which follows the localities in which the samples were taken are also given. Some additional notes have been furnished in regard to some of the samples, which will be of interest. For these notes I am indebted to Capt. D. G. Purse, of Savannah.

Duke Station, Fla.—Samples Nos. 22646–22647.

The top soil is in the top of the bag and the subsoil in the bottom of bag, with a string in the center to keep them separate. The water in this locality is soft, and the land is what is classed as high flat woods, sloping to the north. The field from which this sample was taken consists of about 40 acres and has been under cultivation for about fifteen or twenty years. No fertilizer was used until this year, when a cheap manure, consisting of rock phosphate, kainit, and cotton-seed meal, thoroughly mixed together, was employed. Recently a little compost was applied. The crops that have been raised in this field are corn, cotton, and sugar cane. The railroad runs through this field and the cut is from 1 to 5 feet deep, and there is quicksand in it in wet weather. No rocks or stones in land.

Griffing Station, Fla.—Samples Nos. 22648–22649.

Prepared in the same manner as samples Nos. 22646–22647. The land is high flat woods, slightly rolling. Sample taken from land sloping north and south, with ditch between. Wells 8 to 10 feet deep; soft water. This sample of soil is from a virgin field, planted about two months ago in peaches. The land has been plowed but once. Fertilizer has never been used. Land free from rocks and stones.

Samples Nos. 22650–22651 are from Milepost 38 and taken from virgin soil.

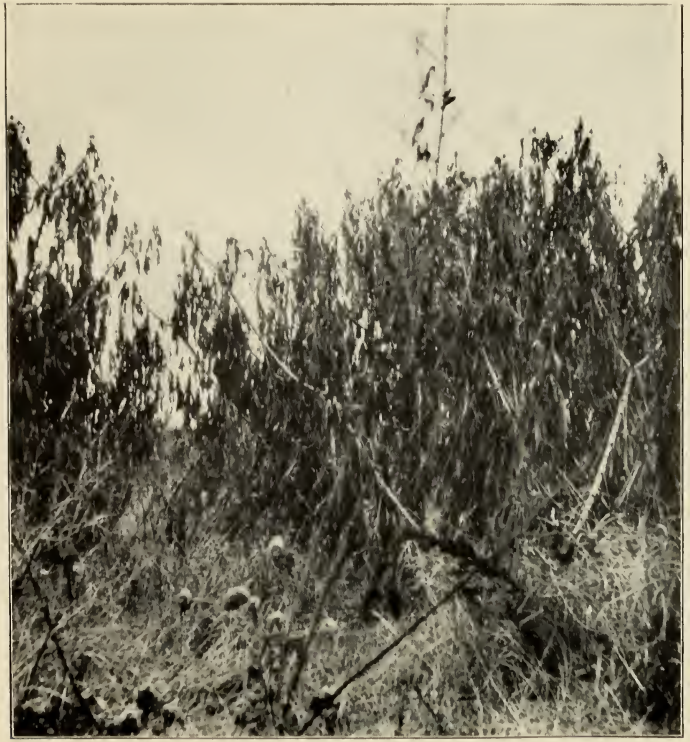

FIG. 1.—FIELD OF CASSAVA ON MCREE'S PLANTATION, KINDERLOU, GA.

FIG. 2.—J. B. WIGHT'S CANE-SIRUP FACTORY, CAIRO, GA.

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FIG. 1.—GEORGIA SUGAR CANES AT WAYCROSS, GA.

FIG. 2.—MR. HATCHER'S SIRUP MILL NEAR WAYCROSS, GA.

SAMPLES NOS. 22652, 22653.

This sample is taken from George Britt's place at Milepost 41. Water soft. Field has been under cultivation thirty years. High, flat woods. Fertilized with a cheap manure, 200 pounds to the acre. Crops raised in this field consist of cotton, corn, and sugar cane. I would call your attention to the fact that in this field there is a disease in the cotton called "black root." The root turns black and the plant dies. Mr. Britt would like to know if this is caused by the soil; if so, what can be done to remedy it.

SAMPLES NOS. 22654, 22655.

This sample is from Milepost 46. High, flat woods, and remarkably rich. The sample was taken from virgin soil in the pine woods. Water soft. Well 10 to 12 feet deep.

The farms from which these samples have been taken have from 1 to 3 acres in sugar cane, and they raise from 10 to 12 barrels of sirup to the acre.

It must be remembered that the section of the country through which the Jacksonville and Southwestern Railroad runs is entirely a new country, nearly all of the land being virgin, with here and there a few places which have been in cultivation for years. This virgin soil with a little assistance should produce from 10 to 15 barrels of sirup to the acre.

EGYPT, GA.—SAMPLES NOS. 22658, 22659.

Land owned by Mr. E. E. Foy. This land has been in cultivation twenty-eight years. This year and last it was planted in cane. It was planted in rye in 1899, on which no fertilizer was used. The fertilizer used on cane crop both this year and last was stable manure, about a ton per acre, supplemented with about 200 pounds each of cotton-seed meal and acid phosphate. Land level and sandy.

ADRIAN, GA.—SAMPLES NOS. 22660, 22661.

Land owned by Capt. T. J. James. Land at present planted in cane; also last year. Formerly planted in corn and oats. Each crop fertilized with about 200 pounds of guano. Land level and sandy; free from stones; not very well drained. This land has only been in cultivation about five years.

AMERICUS, GA.—SAMPLES NOS. 22662, 22663.

Land owned by Mr. Tawson; rented by Stapleton for several years. Land has been in cultivation twenty years or more. A small creek within 300 yards of the edge of the field. Rather rolling, with a stiff clay subsoil. The field from which this sample is taken is typical of the land upon which cane is usually grown, rather than typical of the general soil of the locality. This land was in cane last year, but this season is not planted in anything. Fertilizer used last year and the year before consisted of 200 pounds of cotton-seed meal and 150 pounds of acid phosphate.

ALBANY, GA.—SAMPLES NOS. 22664, 22665.

Land owned by Mr. Morris Wesloski. This sample is taken from land which is at present in Irish potatoes and was in cane for two years preceding. Fertilizer used on the land this year was about 600 pounds of guano per acre. On the cane the same fertilizer was used, about 400 pounds per acre. Land is level, a dark loam. Field from which sample was taken is typical of the whole locality.

HARTFORD, ALA.—SAMPLES NOS. 22666, 22667.

Land owned by J. W. McKinney. Has been in cultivation about seven years. At present is planted in cane; last year in sweet potatoes. Samples taken from a

field typical of the locality. Rather rolling, sandy, well drained. About 200 pounds of guano per acre was used on both the cane and sweet potatoes. This was supplemented with a little stable manure.

The three samples sent were taken from along the Chattahoochee River, but in different localities, the samples differing considerably.

COLUMBIA, ALA.—SAMPLES NOS. 22668, 22669.

Land owned by J. F. Bowden. Samples taken from a field adjoining a creek, about 3 miles from the river. This field is typical of what is called the "upland" bottoms, as distinguished from the first and second bottoms. This land is well drained, rather sandy and level. A very stiff clay subsoil about 3 feet below surface. Samples taken from an oat field where corn was planted last year. One hundred and fifty pounds of guano was used on oats; about the same on corn. This land has been in cultivation for about fifteen years.

GEORGETOWN, GA.—SAMPLES NOS. 22670, 22671.

Land owned by H. Lampley. These samples are from a field of "second bottom" land. Is subject to overflow from backwater in very high water. Is about one-fourth of a mile from the river. Land level, sandy. Has been in cultivation for thirty years or more. At present is planted in cotton; formerly in corn. Fertilizer used on both crops was about 150 pounds of guano per acre.

BRICKYARD, ALA.—SAMPLES NOS. 22672, 22673.

Land owned by Mr. G. M. Flournoy. Samples taken from "first bottom" land, about 1 mile from the river. Subject to overflow every year. Has been in Johnson grass for seven years. A very rich black soil. No fertilizer used. Cultivated for fifty years or more. Level, poorly drained.

FITZGERALD, GA.—SAMPLE NO. 22943.

Land planted by R. A. Wilson. This soil has been treated in the manner prescribed in your letter. During the last three years I have grown on this tract corn, potatoes, peas, watermelons, and various other crops, the most of which have produced two or three crops each year. Of course, I fertilize each crop some, the fertilizer used being phosphate and German kainit and barn manure.

AMBROSE, GA.—SAMPLE NO. 22944.

Land planted by C. H. Buttler. Field has been in cultivation for six years, and the following crops have been grown: Cotton, corn, potatoes, and sugar cane.

BEACH, GA.—SAMPLE NO. 22945.

This soil was taken from a field now in cultivation for the third season. The first season it was planted in sweet potatoes with poor success, it being too wet for the crop. The second season it was planted in sugar cane, with splendid results. It is now planted for the third season in sugar cane and promises to do well. Stable manure has been used freely each season.

DOUGLAS, GA.—SAMPLE NO. 22946.

This field has been in cultivation for thirty years. Corn, cotton, and cane have been the principal crops raised almost every year on this land. Good crops have been made almost every year. From 300 to 350 pounds of commercial fertilizer has been used almost every year.

SAMPLES NOS. 22949–22950.

Soil and subsoil of red clay land. Oak and hickory; in cultivation sixty or seventy years.

SAMPLES NOS. 22951–22952.

Soil and subsoil of poor sandy soil; in cultivation seventy years.

COLLECTION OF THE SAMPLES.

All the samples of soil were collected by Captain Purse. The following directions were sent from this Bureau for securing the soils and subsoils:

Samples of soil are to be taken in the following manner, and the locality should be selected which is typical of the neighborhood. By means of a spade from 10 to 20 pounds of soil should be removed from at least half a dozen different points in the field. Select them so as to have them as nearly typical of the whole field as possible. These samples should be put together on a hard, dry floor or oilcloth spread upon the ground, and thoroughly mixed, removing all stones and pebbles, sticks and roots. The residue should then be quartered and one-quarter saved and the other three-quarters rejected. This quarter should again be mixed thoroughly and again quartered, and this process continued until the sample weighs 4 pounds or less. This sample should be placed in a strong cloth bag, sewed up, and the franks I send you securely tied thereto.

It is important to have also a sample of the subsoil in each locality. The samples of the soil are taken to the usual depth of plowing or to where the change in color of the soil is noticed—say, from 5 to 9 inches, according to circumstances. After the soil is removed from this excavation carefully, a sample of the subsoil should be taken to a depth of from 5 to 7 inches below the soil sample. The mixing and quartering of the subsoil should be accomplished in the manner described above.

In each case the previous history of the field, the character of the crops grown on it, and the kind of fertilization, if any, it has received are to be noted. There should also be given any prominent geological features of the neighborhood, the character of the stones and rocks, character of the water, contour of the land, etc.

ANALYSES OF SOILS.

Each sample was submitted to two chemical analyses. One, to determine the total quantity of substance soluble in hot concentrated hydrochloric acid, was conducted according to the methods prescribed by the Association of Official Agricultural Chemists (Bul. 46, pp. 71 et seq.). The number of parts of potash and phosphoric acid soluble per million in N/200 hydrochloric acid was obtained according to the method of Moore (Journal of the American Chemical Society, vol. 24, No. 1, p. 79). These analyses were made by Mr. C. C. Moore.

The mechanical analysis of the soils was made according to the method of Osborne (Principles and Practice of Agricultural Analysis, vol. 1, pp. 196 et seq.), by Mr. F. M. Cockrell, under direction of Mr. C. C. Moore.

Analyses of soils in Georgia, North Carolina, Alabama, and Florida on which sugar cane is grown.

Serial number.	Soluble in HCl. sp. gr. 1.115.										Soluble in N/200 HCl. (Parts per million.)		Mechanical composition								Soil.	Location.
	Per cent insoluble residue.	Per cent K_2O.	Per cent CaO.	Per cent MgO.	Per cent Fe_2O_3.	Per cent Al_2O_3.	Per cent P_2O_5.	Per cent SO_3.	Per cent N.	Per cent humus.	K_2O.	P_2O_5.	Per cent >.25 mm.	Per cent >.10 mm.	Per cent >.05 mm.	Per cent >.025 mm.	Per cent >.012 mm.	Per cent >.006 mm.	Per cent will not float 18 hours.	Per cent will float 18 hours.	Per cent loss on ignition.		
22441	98.950	Tr	0.025	0.028	0.100	0.018	0.012	0.010	0.022	0.44	32	14	8.6	79.2	7.8	0.6	0.5	0.6	0.3	1.8	0.6	Soil	Manatee River, Fla.
22442	96.720	Tr.	.025	.021	.075	.245	.014	.019	.079	1.48	85	20	8.4	65.6	19.3	0.6	0.4	0.2	0.7	1.0	3.8	Soil	Do.
22443	97.970	Tr.	.020	.016	.075	.022	.035	.013	.042	.62	29	5	46.5	36.6	10.2	1.3	1.6	0.4	1.1	0.8	1.5	Soil	McIntosh, Fla.
22444	99.120	Tr.	.020	.010	.100	.283	.024	.013	.021	.24	29	20	41.9	39.3	12.8	1.3	1.2	0.6	1.2	1.3	0.4	Subsoil	Do.
22445	93.460	Tr.	.070	.040	.400	1.460	.015	.015	.051	1.04	50	1	36.0	33.9	13.7	2.4	3.2	1.0	3.3	2.6	3.9	Soil	Iron City, Ga.
22446	95.265	Tr.	.040	.031	.525	1.814	.161	.010	.028	.80	53	1	37.7	33.3	12.6	3.6	3.4	2.5	1.2	3.8	1.9	Subsoil	Do.
22447	91.475	Tr.	.050	.049	.425	1.990	.034	.018	.112	2.24	82	3	25.0	47.0	13.6	2.2	2.3	0.5	2.1	1.1	6.2	Soil	Quitman, Ga.
22448	94.605	Tr.	.012	.020	.375	2.025	.025	.014	.055	1.00	57	2	24.8	48.4	15.9	2.4	2.3	1.1	0.9	1.7	2.5	Subsoil	Do.
22449	90.650	0.373	.021	.072	2.550	1.666	.026	.015	.070	1.08	69	2	25.4	42.7	16.1	2.4	2.5	2.2	1.4	2.6	4.7	Soil	Pronto, Ala.
22450	83.665	Tr.	.092	.090	6.275	4.882	.074	.014	.049	1.44	76	2	20.7	34.2	10.7	4.8	2.2	2.6	1.5	19.1	4.2	Subsoil	Do.
22451	89.375	Tr.	.062	.035	.600	2.011	.021	.024	.126	2.64	62	6	12.8	26.3	6.9	12.2	21.3	5.6	1.4	6.6	6.9	Soil	Yemassee, S. C.
22452	91.965	Tr.	.070	.090	.550	2.086	.014	.017	.067	2.14	382	3	16.8	27.9	10.8	11.4	21.8	Tr.	0.2	6.5	4.6	Subsoil	Do.
22453	92.255	Tr.	.142	.054	.400	2.064	.561	.010	.055	1.82	47	12	20.7	44.0	22.0	1.6	2.3	0.2	0.1	4.7	4.4	Soil	Fort Meade, Fla.
22454	86.693	Tr.	.090	.028	.625	3.895	.485	.015	.070	1.10	65	3	21.4	43.0	19.5	5.2	0.9	0.7	1.3	1.4	6.6	Soil	Do.
22646	97.290	Tr.	.020	.019	.050	.321	.036	Tr.	.042	.80	51	15	33.2	47.1	13.5	1.6	1.4	0.2	Tr.	0.9	2.1	Soil	Dukes, Fla., old field, Jacksonville and Southwestern Rwy.
22647	98.670	Tr.	Tr.	.013	.100	.350	.012	Tr.	.017	.40	18	4	4.6	71.5	15.8	2.6	1.5	0.2	Tr.	3.0	0.8	Subsoil	Do.
22648	95.785	Tr.	Tr.	.021	.125	.375	Tr.	.012	.056	1.46	50	3	34.0	44.0	14.0	1.8	0.8	0.1	Tr.	1.6	3.7	Soil	Griffin, Fla., virgin soil, Jacksonville and Southwestern Rwy.
22649	97.965	Tr.	Tr.	.009	.100	.590	Tr.	.009	.028	.44	19	1	4.3	74.3	17.3	1.6	0.4	0.1	Tr.	0.9	1.1	Subsoil	Do.
22650	96.365	Tr.	Tr.	.018	.072	.008	Tr.	.012	.045	1.48	41	3	1.1	58.5	26.7	6.0	2.7	0.6	1.2	2.3	0.9	Soil	38 Mile Post, Fla., virgin soil, Jacksonville and Southwestern Rwy.
22651	93.585	Tr.	Tr.	.013	.072	.248	Tr.	Tr.	.022	.46	26	1	1.0	61.0	25.0	4.2	2.1	0.5	1.3	1.8	3.1	Subsoil	Do.
22652	96.955	Tr.	.012	.018	.225	1.357	Tr.	Tr.	.021	.65	20	1	1.4	63.3	24.6	5.0	1.7	0.5	1.2	1.1	1.2	Soil	Geo. Britt, Fla., Mile Post 40, Jacksonville and Southwestern Rwy.
22653	96.955	Tr.	.020	Tr.	.100	.630	Tr.	.027	.055	.90	42	1	1.2	62.3	24.9	5.8	1.2	0.5	1.0	1.0	2.1	Subsoil	Do.

22654	94.260	Tr.	.010	Tr.	.150	.490	Tr.	.016	.070	1.36	55	2	8.2	50.8	26.1	7.1	1.8	0.5	1.0	0.9	3.6	Soil	Rainford, Fla., virgin soil, Jacksonville and Southwestern Rwy.
22655	92.675	Tr.	.010	Tr.	.225	.835	Tr.	.018	.028	.54	39	1	8.0	49.6	30.3	7.5	1.8	0.5	0.8	0.3	1.2	Subsoil	Do.
22656	63.190	.109	.075	.171	2.725	9.191	.084	.054	.410	6.56	95	3	13.4	17.9	10.2	7.1	2.1	2.6	7.9	19.2	19.6	Soil	Liberty City, Ga., Plant System Rwy.
22657	77.555	Tr.	.182	.142	2.125	7.125	.045	.034	.230	2.48	87	3	15.9	18.3	12.4	4.4	1.9	2.9	7.2	24.9	12.1	Subsoil	Do.
22658	95.495	Tr.	.142	.029	.200	.676	.044	.029	.073	1.58	73	4	17.0	45.7	15.8	7.6	2.1	2.0	1.4	1.0	3.4	Soil	Egypt, Ga., cultivated 28 years, E. E. Foy.
22659	97.650	Tr.	.030	.025	.250	.815	.005	.012	.017	.51	47	2	17.0	48.6	13.1	13.8	1.8	1.7	1.3	1.5	1.2	Subsoil	Do.
22660	98.115	Tr.	.030	.030	.300	.755	.002	.012	.028	.49	115	5	24.3	54.3	5.9	9.3	1.0	0.9	2.3	1.1	0.9	Soil	Adrian, Ga., T. J. James.
22661	90.375	Tr.	.062	.036	.300	.647	.028	.022	.045	1.00	146	12	26.7	51.3	9.6	5.0	2.0	0.6	1.6	0.7	2.5	Subsoil	Do.
22662	94.660	Tr.	.060	.054	.700	1.272	.040	.027	.062	1.34	134	6	39.6	30.2	7.9	12.3	3.2	1.2	1.4	1.4	2.8	Soil	Americus, Ga., cultivated 20 years, T. Stapleton.
22663	73.725	.342	.190	.463	6.00	9.160	.026	.022	.070	3.24	108	1	5.4	6.2	3.3	32.8	11.1	0.5	13.9	26.7	10.1	Subsoil	Do.
22664	92.565	Tr.	.195	.070	1.000	2.970	.051	.025	.039	1.46	98	7	54.0	20.3	1.7	8.2	4.2	0.4	3.2	1.7	3.3	Soil	Albany, Ga., M. Wesloski.
22665	87.325	Tr.	.050	.030	1.785	4.157	.038	.015	.042	2.82	85	1	35.0	24.3	1.8	9.0	2.9	4.9	1.0	17.2	3.9	Subsoil	Do.
22666	92.955	Tr.	.060	.067	.450	2.623	.014	.031	.039	.96	64	3	47.8	25.8	3.2	9.3	5.5	2.1	1.2	1.8	3.3	Soil	Hartford, Ala., cultivated 7 years, J. W. McKinney.
22667	93.400	Tr.	.025	.153	.870	3.343	.012	.027	.017	1.14	50	1	47.3	23.2	3.5	13.5	2.4	2.8	4.7	0.4	2.2	Subsoil	Do.
22668	91.362	.095	.072	.255	1.350	3.135	.035	.009	.042	.70	76	2	10.7	42.6	7.5	20.1	3.9	2.2	5.9	3.8	3.3	Soil	Columbia, Ala., upland bottom, J. T. Bowden.
22669	89.545	.093	.072	.162	1.725	3.637	.018	.012	.062	1.20	70	2	6.8	40.8	7.4	23.8	4.4	3.7	1.5	9.2	2.4	Subsoil	Do.
22670	96.195	Tr.	.045	.046	.750	1.167	Tr.	.006	.035	.42	230	3	19.9	43.6	17.2	12.2	1.9	1.5	2.4	0.2	1.1	Soil	Georgetown, Ga., second bottom, H. Lampley.
22671	87.105	.121	.080	.242	2.550	5.960	.031	.009	.042	1.62	76	2	15.4	33.2	8.1	13.3	2.3	1.9	6.6	15.7	3.5	Subsoil	Do.
22672	72.825	.320	.210	.579	4.425	11.440	.074	.022	.112	.46	97	2	0.1	1.1	1.8	40.4	14.0	13.0	15.2	5.2	9.2	Soil	Brickyard, Ala., first bottom, G. M. Flournoy.
22673	76.830	.268	.425	.475	3.925	9.296	.091	.025	.098	3.32	34	1	0.1	4.0	4.3	45.2	10.5	7.3	10.0	10.5	8.1	Subsoil	Do.
22943	94.005	Tr.	.080	.033	.575	6.237	.027	.009	.042	1.08	72	4	26.0	33.0	14.0	15.0	3.0	1.5	2.6	1.1	3.8	Soil	Fitzgerald, Ga., W. A. L. Rwy.. R. A. Wilson.
22944	92.560	Tr.	.117	.033	.725	1.475	.012	.012	.062	1.32	58	2	39.2	31.5	7.0	8.6	3.4	0.4	1.8	3.4	4.5	Soil	Ambrose, Ga., W. A. L. Rwy., C. H. Buttler.
22945	95.300	Tr.	.030	.049	.200	.496	.029	.009	.077	1.26	119	6	30.3	34.6	14.5	13.8	0.9	2.1	0.5	0.1	3.2	Soil	Beach, Ga, W. A. L. Rwy.
22946	96.965	Tr.	.242	.031	.400	.400	.027	.007	.084	.80	77	9	31.4	34.6	11.2	16.3	1.6	1.3	0.7	0.7	2.3	Soil	Douglas, Ga., W. A. L. Rwy.
22947	94.890	Tr.	.100	.036	.250	.650	Tr.	.009	.039	1.02	63	2	54.3	21.9	2.8	9.4	2.1	5.0	0.7	0.6	3.2	Soil	Eastman, Ga., Southern Rwy., Park Harper.
22948	96.580	Tr.	.060	.040	.275	.667	Tr.	.009	.033	.76	66	2	55.6	22.2	5.2	8.2	2.0	3.2	0.7	0.8	2.1	Subsoil	Do.
22949	90.097	.042	.080	.056	1.550	2.095	.030	.024	.034	1.68	55	1	36.6	24.8	5.8	12.1	4.7	3.0	3.8	5.8	3.4	Soil	East Macon district, Bibb County, Ga., Southern Rwy., B. D. Lumsden.
22950	83.622	.085	.080	.111	2.825	6.280	.037	.013	.034	2.70	31	1	23.3	21.8	4.6	10.4	9.3	1.7	6.2	18.0	4.7	Subsoil	Do.
22951	97.077	Tr.	.042	.029	.375	1.152	.014	.013	.028	.64	30	3	57.8	24.6	3.2	6.5	2.6	1.5	1.2	1.1	1.5	Soil	Do.
22952	93.822	Tr.	.042	.061	.900	3.230	.045	.022	.026	1.10	42	1	53.9	21.4	2.3	13.3	2.7	2.0	0.9	1.2	2.3	Subsoil	Do.

Analyses of soils in Georgia, North Carolina, Alabama, and Florida on which sugar cane is grown—Continued.

Serial number.	Soluble in HCl. sp. gr. 1.115.										Soluble in N/200 HCl. (Parts per million.)		Mechanical composition.							Soil.	Location.
	Percent insoluble residue.	Per cent K_2O.	Per cent CaO.	Per cent MgO.	Per cent Fe_2O_3.	Per cent Al_2O_3.	Per cent P_2O_5.	Per cent SO_3.	Per cent N.	Per cent humus.	K_2O.	P_2O_5.	Per cent >.25 mm.	Per cent >.10 mm.	Per cent >.05 mm.	Per cent >.025 mm.	Per cent >.012 mm.	Per cent >.006 mm.	Per cent will not float 18 hours.	Per cent will float 18 hours.	Per cent loss on ignition.		
22953	93.157	Tr.	0.070	0.015	0.600	1.516	0.034	0.027	0.067	1.48	104	2	7.6	39.6	20.1	20.7	2.6	2.6	1.9	1.2	3.7	Soil	Gardi, Wayne County, Ga., Southern Rwy.
22954	95.875	Tr.	.020	.013	.675	2.730	.007	.013	.022	.88	55	2	9.1	41.4	17.2	21.0	2.8	4.2	0.8	2.0	1.5	Subsoil	Do.
22955	96.147	Tr.	.262	.047	.125	.245	.054	.010	.062	.90	90	32	34.6	40.7	4.8	11.7	2.5	1.9	0.5	0.4	2.9	Soil	Baxley, Appling County, Ga., Southern Rwy., Geo. D. Lowe.
22956	92.217	Tr.	.045	.014	.150	.783	.017	.010	.031	.66	100	2	35.5	41.1	6.3	11.4	1.9	1.4	0.4	0.2	1.8	Subsoil	Do.
22957	87.450	Tr.	.100	.027	.600	2.268	.024	.022	.062	1.50	34	17	17.1	49.3	9.1	14.9	1.4	2.7	0.7	0.9	3.9	Soil	Quincy, Glasden County, Fla., Seaboard Air Line Rwy.
22958	94.600	Tr.	.042	.020	.600	2.523	.007	.027	.026	1.08	42	2	16.8	48.7	6.5	18.3	1.6	2.9	1.1	1.9	2.2	Subsoil	Do.
22959	96.135	Tr.	.045	.016	.200	.677	.074	.007	.043	.76	24	2	26.0	38.7	5.3	24.1	1.9	1.2	0.5	0.1	2.2	Soil	Madison, Madison County, Fla., Seaboard Air Line Rwy.
22960	96.000	Tr.	.055	.013	.200	.652	.090	.009	.047	.86	42	15	20.3	41.8	17.8	14.6	1.2	1.4	0.2	0.4	2.3	Subsoil	Do.
22961	94.812	Tr.	.062	.006	.400	.670	.022	.015	.051	1.14	72	8	23.0	30.0	11.2	21.2	5.0	3.8	1.1	1.7	3.0	Soil	Scotia, S. C., Seaboard Air Line Rwy., John Lawton.
23577	95.535	Tr.	.107	.010	.500	1.350	.014	.012	.034	.88	27	2	38.0	35.4	7.1	12.0	1.9	2.3	0.3	0.7	2.3	Soil	Chipley, Fla.
23578	94.212	Tr.	.037	.009	.750	2.592	Tr.	.004	.017	1.14	42	1	35.1	34.3	6.2	11.1	2.6	3.3	1.5	4.0	1.9	Subsoil	Do.
23579	82.645	.053	.342	.091	2.450	6.765	.312	.022	.101	2.32	60	1	22.3	28.7	12.0	16.6	5.9	3.8	0.4	2.8	7.5	Soil	Marianna, Fla.
23580	95.170	Tr.	.032	.002	.475	1.582	.007	.013	.051	1.00	36	5	37.3	30.7	10.3	11.7	2.4	2.5	0.7	1.4	3.0	Soil	Grand Ridge, Fla.

NOTES ON SOIL ANALYSES.

The most striking feature exhibited by the above table is found in the fact that the soils represented are almost pure sand. In one instance more than 99 per cent of the soil is insoluble in strong, hot hydrochloric acid, while the number of soils containing more than 95 per cent of insoluble matter is very large. The only soils in the list which are not decidedly of a sandy nature are Nos. 22450, 22454, 22656, 22657, 22663, 22665, 22671, 22672, 22673, 22950, 22957, and 23579. Of these a few are distinctly vegetable or humus soils, viz, 22656, 22657, and 22663. All three of these soils contain large quantities of humus and other organic matter.

The second characteristic of the soils, which is very prominently shown in the table of analyses, is the absence of any large quantity of potash soluble in hot hydrochloric acid. Only the following soils contain notable quantities of soluble potash, viz, 22449, 22663, 22672, and 22673.

Phosphoric acid is also deficient in most of the soils, but not to the same extent as potash. One of the soils and the subsoil going with it, viz, Nos. 22453 and 22454, have a very high quantity of phosphoric acid, and these samples, as will be seen, were from Florida, in the vicinity of the heavy phosphate deposits of that State.

The other mineral constituents of soils are less important, viewed as plant food. Two of these, however, are found constantly in plants, viz, lime and magnesia. As is to be expected in soils of this character, these two mineral constituents are deficient in quantity as compared with the standard of soils of the usual texture. In a few of the soils there is an abundant supply of iron and alumina, and these could be classed as clay soils in which the percentage of clay is not very large. Among the most prominent of this type are Nos. 22656, 22657, 22663, 22672, 22673, 22943, and 23579.

The percentage of nitrogen in all the soils, with the exception of two or three of the vegetable soils, is quite low, and also, as would be expected, the quantity of humus. In only three instances does the percentage of humus rise above 3. Evidently these are soils which are not well suited to retain nitrogen constituents for any great length of time. In fact, one of the chief physical characteristics of these soils is the ease with which water percolates through them and the consequent rapidity with which soluble substances are leached out during heavy rains.

In the estimation of potash and phosphoric acid, by dilute hydrochloric acid, the purpose in view is to secure some idea, not of the total quantity of these plant foods present in any given sample, but of their relative availability. Pot experiments made by this Bureau have shown that a reasonably good approximation to the available plant food in a soil may be made by treating a sample of it with N/200

hydrochloric acid at a constant temperature of 40° C., with continuous shaking. This process applied to the soils in question show that the potash, although present in extremely minute quantities in most of the soils, is very highly available; that is, practically all the potash in the soil is at the disposition of the growing plant. On the contrary, the phosphoric acid which exists in these soils, as a rule in much larger quantities than potash, has a very much lower degree of availability. Therefore, while a growing crop might take out all of the potash in a soil, it would remove only a small quantity of the phosphoric acid present. In other words, the phosphoric acid which is present is so locked up in mineral combination as to be largely insoluble in dilute, cold, or lukewarm hydrochloric acid at the temperature mentioned.

These figures show that the potash present in the soil is practically all available for the growing crop, and the crop therefore takes as much of it as may be necessary to meet its demands. On the contrary, the growing crop is able to take only a small fraction of the phosphoric acid present. Hence it appears that the general rule to be followed in the case of these soils is to give them largely the two essential elements of plant food which are least available in the quantities in which they exist in the soil, viz, phosphoric acid and nitrogen.

Of course there are many of these soils in which potash is also deficient, but it is evident that the quantity which is present, although minute, is very highly available. As a rule, therefore, if any one of the three essential elements of plant food is omitted in the fertilizer applied it would be safer to leave out potash than either phosphoric acid or nitrogen. At the same time it is evident that in many of the cases the judicious application of potash would be highly advisable.

In this connection, however, it must be remembered that, as a rule, plants take a larger quantity of potash from the soil than of phosphoric acid, and hence the presence of available potash, as determined by the dilute hydrochloric acid method in two or three times the quantity of available phosphoric acid, would indicate that the soil was in equal need of both phosphoric acid and potash in case either was necessary to make the crop.

Illustrations of what is meant by this can best be drawn from the table of analyses above. For instance, in No. 22441 the potash soluble in hydrochloric acid is 32 parts per million and the phosphoric acid 14. This soil needs potash even more than phosphoric acid. In the next number the proportions are as 85 to 20, respectively. This is a soil in which phosphoric acid is probably needed more than potash. In the next number the proportions are 29 to 5. Here both elements are deficient, but phosphoric acid in a more marked degree than potash. For the next number the proportions are 29 to 20. This is a soil which needs especially potash. In the next numbers the proportions are as 50 to 1 and 53 to 1, and, in fact, in many of the numbers

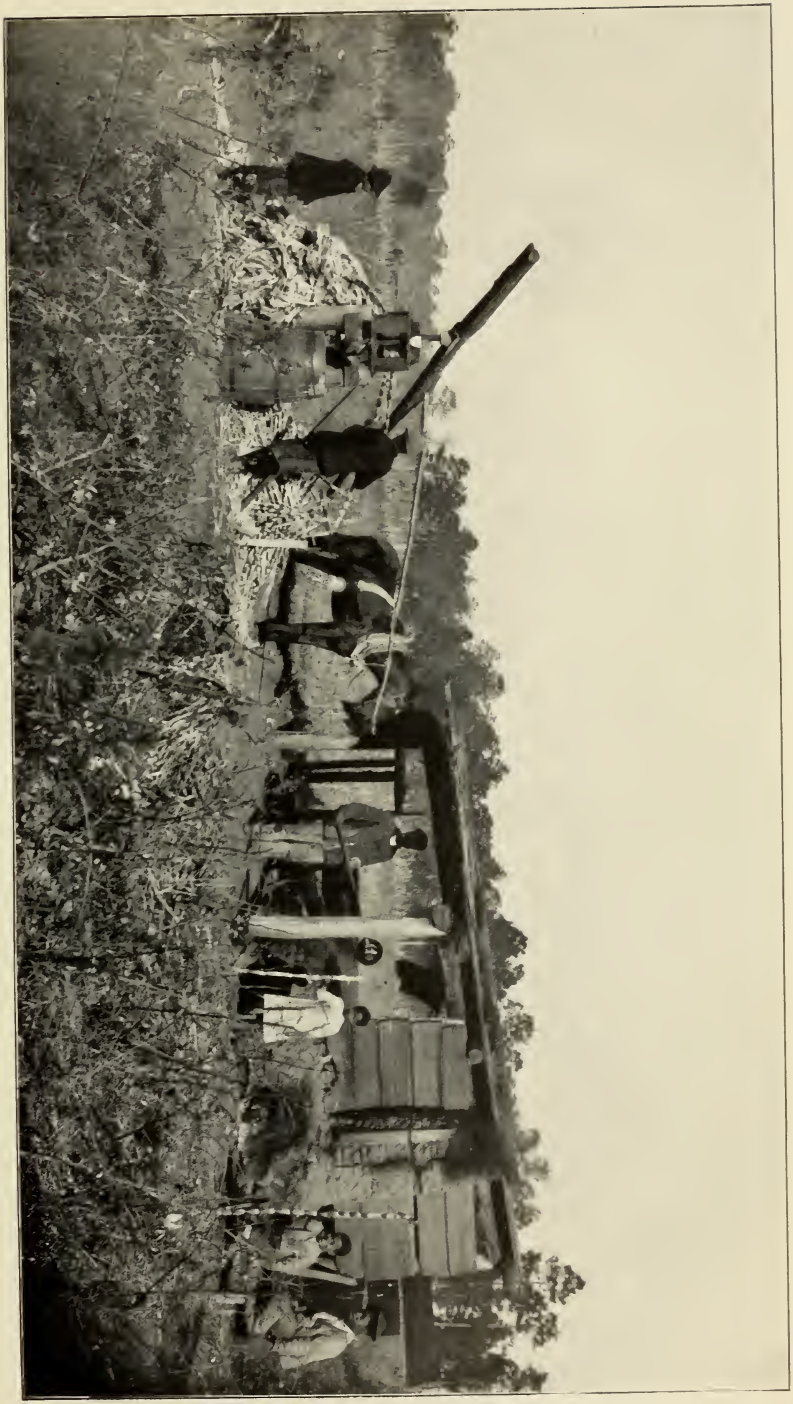
FIG. 1.—METHOD OF FEEDING CANE IN MR. HATCHER'S MILL.

FIG. 2.—METHOD OF FEEDING CANE IN MR. HATCHER'S MILL—SECOND VIEW.

FIG. 1.—EVAPORATOR IN MR. HATCHER'S MILL.

FIG. 2.—FURNACE IN MR. HATCHER'S MILL.

FACTORY OF E. A. VANLANDINGHAM, NEAR CAIRO, GA.



FACTORY OF WILLIAM LOMAX, NEAR CAIRO, GA.

down to 22453 the data show that phosphoric acid is urgently needed. In fact, there are very few of these soils in which the available phosphoric acid is as large as is required.

The mechanical composition of the soils gives valuable data in regard to their physical texture and capabilities of supporting plant life. A soil must not only have plant food in an available form which it can offer a growing crop, but it must also be of such a texture as to permit the rootlets of the plants to penetrate all parts of the surface in which the available plant root is held. Sandy soils are easily perforated by the roots of plants, and for this reason, although as a rule they are deficient in plant foods, by judicious treatment they may be made to yield large and remunerative crops.

In the table of analyses the mechanical composition of the soils shows the relative proportion of particles of given diameters. The first column shows the percentage of particles larger than 0.25 mm, the second those smaller than 0.25 mm but larger than 0.10 mm, and so on throughout the list. When the particles become too small for convenient measurement, they are separated by suspension in water. Those that are smaller than 0.006 mm. which will not float for eighteen hours, are given in one column and those smaller than 0.006 mm. which will float for eighteen hours in another. In the last two columns is given the loss on ignition, which includes both water and organic matter, while in the last column is given the percentage of water in each sample at the time of analysis. By subtracting the percentage of water from the total loss on ignition the relative quantity of organic matter in each sample can be obtained.

ANALYSES OF SUGAR CANES.

Through Capt. D. G. Purse, of Savannah, arrangements were made to secure samples of sugar canes grown, not only in the localities where the samples of soil were secured, but also in many other places. Instructions for securing and forwarding the samples were prepared as follows:

When the cane appears to be matured, or at the usual time of harvesting, select a stalk from an inside row. The stalk selected should be from a part of the field that represents average conditions.

Cut the stalk, after removing the leaves, into several short pieces and, immediately after, dip the ends of the pieces into melted paraffin, or, preferably, into a mixture of paraffin and beeswax. Wrap the pieces of cane carefully in strong paper. Fill in the blanks on the back of the shipping tag herewith and attach it to the package and mail the latter to the United States Department of Agriculture. No postage is required.

The packages should be mailed so as not to reach Washington on Saturday or Sunday.

Numerous samples of cane, secured in accordance with these instructions, were forwarded for analysis, the first samples reaching

the laboratory early in November, 1901, while the last samples were not received until January, 1902. Samples were received from the States of Alabama, Florida, Georgia, and South Carolina. These samples, on their reception at the laboratory, were immediately subjected to analysis for the purpose of determining the specific gravity, sugar or sucrose, and reducing sugar or glucose, contained in the juices thereof. From the data secured the coefficient of purity—that is, the percentage of pure sucrose or sugar in the dry matter of the juice—was calculated.

The juices of sugar canes may be said to comprise about 90 per cent of the total weight of the canes. Therefore the percentage of the ingredients given in the canes themselves would be, in round numbers, 10 per cent less than in the juice. For instance, if the sucrose or pure sugar in the cane juices amounted to 13.2 per cent, the corresponding percentage of sugar in the cane would be 11.9 per cent.

The analytical data, which were determined chiefly by Mr. Arthur Given, assisted by Mr. F. M. Cockrell, have been arranged alphabetically by States and counties, and are found in the table following.

Analyses of samples of sugar canes, by States and counties.

Serial No.	Date received.	State and county.	Post-office.	Experimenter.	Composition of the juice.			
					Total solids.	Sucrose.	Reducing sugar.	Purity coefficient.
		ALABAMA.			*Per cent.*	*Per cent.*	*Per cent.*	
18	Nov. 11	Geneva □	Hartford	J. W. Wynn	16.4	12.4		75.6
21	..do	..do	do	C. B. Berch	16.0	11.4		71.2
22	..do	..do	do	S. J. Wynn	18.2	15.4		84.6
26	Nov. 12	..do	Highbluff	R. M. Renfro	16.8	12.2	1.47	73.5
13	Nov. 11	Henry □	Columbia	A. Davis	17.2	14.5		84.3
17	..do	..do	do	S. M. Dunwoody	17.3	14.8		85.5
19	..do	..do	do	J. F. Bowden	18.3	15.6		85.2
20	..do	..do	do	A. W. Wood	14.4	10.0		69.4
27	Nov. 12	..do	Dothan	Mrs. Peterman	15.6	12.3	1.60	78.8
28	..do	..do	do	E. Nix	16.9	14.1	1.04	83.4
29	..do	..do	do	J. P. Folks	17.4	14.1	.84	79.6
72	Nov. 21	Pike □	Pronto	J. H. Stephens	15.2	11.4	1.54	75.0
		State average (12 samples)			16.7	13.2	1.30	78.8
		FLORIDA.						
112	Nov. 27	Hillsboro ♀	Hillsboro	J. H. Stephens	15.9	13.4	1.08	84.3
113	..do	..do	do	do	14.9	11.9	1.66	79.8
69	Nov. 21	Jackson □	Marianna	F. M. Watson	16.5	13.4	.71	81.2
70	..do	..do	do	do	16.2	12.8	1.00	79.0
68	..do	..do	do	do	16.5	13.5	.81	81.8
93	Nov. 25	..do	Grandridge	J. T. Porter	15.3	13.0	1.43	85.0
92	..do	..do	do	do	15.8	13.6	1.00	86.1
91	..do	..do	do	do	16.4	14.1	1.11	86.0
90	..do	..do	do	do	17.3	15.0	1.25	86.7
116	Nov. 30	Marion □	McIntosh	J. H. Stephens	16.5	13.1	1.66	79.4
117	..do	..do	Ocala	do	14.6	12.1	1.33	82.9
118	..do	..do	do	do	13.5	10.1	1.66	74.8
111	Nov. 27	Osceola ♀	Kissimmee	do	14.5	10.6	1.48	73.1
131	Dec. 17	..do	do	W. L. Van Duzor	14.9	12.2	.50	81.9
132	..do	..do	do	do	15.1	12.1	1.00	80.2
136	Jan. 3	..do	do	do	15.4	12.0		77.9
135	..do	..do	do	do	17.5	13.8		78.9
138	..do	..do	do	do	14.0	9.6		76.1
139	..do	..do	do	do	14.1	9.4		66.7
137	..do	..do	do	do	15.8	12.1		76.5
140	Jan. 15	..do	do	do	16.2	13.2	1.33	81.5

Analyses of samples of sugar canes, by States and counties—Continued.

Serial No.	Date received.	State and county.	Post-office.	Experimenter.	Composition of the juice.			
					Total solids.	Sucrose.	Reducing sugar.	Purity coefficient.
		FLORIDA—continued.						
					Per cent.	*Per cent.*	*Per cent.*	
141	Jan. 15	Osceola ☿	Kissimmee	W. L. Van Duzor	15.1	11.7	.89	77.0
142	....do	.....do	.....do	.....do	15.5	12.5	1.73	80.2
114	Nov. 27	Polk ☿	Lakeland	J. H. Stephens	15.1	11.3	2.22	74.8
		State average (24 samples)			15.5	12.4	1.26	79.7
		GEORGIA.						
46	Nov. 18	Berrien ☿	Tifton	J. H. Stephens	17.9	14.8	.87	82.7
42	....do	Bibb □	Holton	R. E. Park	17.9	15.5	.75	86.6
41	....do	.....do	.....do	.....do	17.6	14.6	.86	82.9
110	Nov. 27	Bryan □	Keller	E. A. Fulton	16.8	14.1	.75	83.9
48	Nov. 18	Bulloch □	Iric	T. B. Thorne	17.6	15.1	.92	85.7
75	Nov. 21	.....do	Statesboro	J. W. Olliff	19.2	16.0	.93	83.3
74	....do	.....do	.....do	.....do	17.3	12.6	2.35	72.8
73	....do	.....do	.....do	.....do	17.7	13.3	1.90	74.7
7	Nov. 11	Calhoun □	Leary	P. E. Boyd	18.7	16.0	.....	85.6
9	....do	.....do	.....do	F. R. Hammond	18.8	16.4	.....	87.2
11	....do	.....do	.....do	Cain Oddison	16.8	13.0	.....	77.4
12	....do	.....do	.....do	J. Taylor	14.5	10.5	.....	72.4
16	....do	.....do	.....do	J. P. Whitaker	18.1	12.3	.....	68.0
52	Nov. 18	Clinch ☿	Dupont	J. H. Stephens	16.0	12.8	1.16	80.0
120	Nov. 30	.....do	.....do	F. B. Sirmons	17.1	13.3	1.74	78.2
121	....do	.....do	.....do	.....do	16.0	10.5	3.34	65.6
44	Nov. 18	Coffee ☿	Pearson	J. H. Stephens	16.2	12.9	1.28	79.6
53	....do	.....do	Douglas	M. Tanner	17.9	15.1	1.09	84.3
61	Nov. 20	.....do	.....do	.....do	17.4	13.4	.77	77.0
67	Nov. 21	.....do	.....do	.....do	16.4	13.1	1.05	79.9
40	Nov. 13	Colquitt ☿	Liberty City	J. H. Stephens	14.9	10.7	.98	71.8
71	Nov. 21	Decatur □	Iron City	.....do	17.3	14.4	.95	83.2
14	Nov. 11	Dougherty □	Albany	T. M. Ticknor	16.9	13.1	.....	77.5
15	....do	.....do	.....do	P. Nelson	18.1	15.5	.....	85.5
45	Nov. 18	.....do	.....do	J. H. Stephens	17.6	15.0	.98	84.7
3	Nov. 8	Effingham □	Tusculum	A. K. Powers	16.2	13.1	.....	80.8
4	....do	.....do	Egypt	E. E. Foy	15.5	11.4	.....	73.5
5	....do	.....do	.....do	A. B. Keifer	14.9	11.3	.....	75.5
6	....do	.....do	Guyton	E. J. Foy	17.1	14.2	.....	83.0
10	Nov. 11	.....do	.....do	A. J. Futrell	17.4	14.9	.....	85.6
23	....do	.....do	.....do	C. A. J. Sweat	18.0	14.8	.....	81.6
24	....do	.....do	.....do	J. C. Fox	14.5	11.2	.....	77.2
25	....do	.....do	.....do	Dr. H. E. Archer	16.5	13.1	.....	79.4

58	Nov. 20	do	do	J. T. Wells	15.9	11.8	1.74	74.2
59	do	do	do	do	15.0	12.0	1.43	75.0
64	do	do	do	Dr. H. E. Archer	16.7	13.4	1.38	80.2
63	do	do	do	J. T. Wells	16.9	14.4	.77	84.7
62	do	do	do	A. J. & W. S. Simmons	18.0	14.5	.67	80.5
65	do	do	do	J. & M. Pevee	15.7	11.7	1.38	71.5
81	Nov. 21	do	Egypt	E. E. Foy	15.0	10.6	1.54	70.7
80	do	do	do	do	14.3	9.6	2.10	67.1
79	do	do	do	do	15.5	11.5	1.43	74.2
82	do	do	do	do	14.0	9.3	2.50	66.4
51	Nov. 18	Emanuel □	Adrian	C. H. Hutchinson	19.2	15.4	1.28	80.2
50	do	do	do	T. J. James	16.5	12.0	2.38	72.7
49	do	do	do	do	15.4	11.3	1.78	73.3
77	Nov. 21	do	do	do	17.1	12.0	2.00	70.2
78	do	do	do	do	16.3	11.6	1.66	75.8
76	do	do	do	do	15.6	9.6	3.33	61.5
83	do	do	do	do	16.3	12.6	.97	77.3
84	do	do	do	do	17.2	12.9	1.43	75.0
85	do	do	do	do	16.4	11.2	2.23	71.3
115	Nov. 30	Glynn □	Brunswick	E. F. Correy	17.6	14.4	1.44	81.8
8	Nov. 11	Haralson □	Bremen	Foy, Dutton & Co	17.1	14.2		83.0
55	Nov. 18	Houston □	Lavilla	D. F. Gunn	18.7	15.9	.82	85.0
54	do	do	do	do	17.8	14.7	.50	82.6
30	Nov. 13	Jefferson □	Wadley	W. M. Beddingfield	17.6	15.3	.91	86.9
31	do	do	do	W. M. Beasley	18.6	15.8	1.16	84.9
32	do	do	do	G. C. Calhoun	18.5	15.7	1.03	84.8
33	do	do	do	Mrs. K. Donovan	17.9	15.8	.57	88.3
47	Nov. 18	Laurens □	Dublin	J. G. Hill	18.6	13.6	2.63	73.1
119	Nov. 30	do	do	G. C. Thompson	14.9	11.1	1.82	74.5
87	Nov. 23	Lowndes □	Kinderlou	McRee Bros	15.8	13.4	1.03	84.8
88	do	do	do	do	16.0	12.9	1.33	80.6
89	do	do	do	do	15.4	12.0	1.82	77.9
43	Nov. 18	Pierce □	Blackshear	J. H. Stephens	17.1	13.7	.91	80.1
126	Dec. 4	Spalding □	Griffin	J. G. Matthews	17.8	13.7	1.74	77.9
57	Nov. 20	Thomas □	Thomasville	J. H. Stephens	15.4	11.6	1.90	75.3
56	do	do	Cairo	J. B. Wight	14.9	9.6	2.75	64.4
60	do	do	do	do	16.3	13.0	1.29	79.8
127	Dec. 4	do	do	do	16.5	13.7	1.03	83.0
128	do	do	do	do	17.5	15.3	1.08	87.7
105	Nov. 25	Ware □		Sampled by H. W. Wiley	15.0	11.0	2.22	73.3
104	do	do		do	15.9	13.1	1.05	82.4
103	do	do		do	17.3	14.4	1.25	83.2
102	do	do		do	17.2	14.1	1.33	82.0
101	do	do		do	15.8	12.7	.95	80.4
109	do	do		Dr. J. M. Spencer	16.3	13.0	1.25	79.9
108	do	do		J. T. Thigpen	17.2	14.8	.67	86.0
106	do	do		Dr. J. M. Spencer	15.0	10.6	2.00	70.7
107	do	do		M. Woodood	16.6	13.1	1.54	78.9
96	do	do	Waresboro	J. M. Spencer	17.0	14.9	.69	87.6
95	do	do	do	do	17.1	14.9	.80	87.1
94	do	do	do	do	16.9	14.7	.77	87.0

Analyses of samples of sugar canes, by States and counties—Continued.

Serial No.	Date received.	State and county.	Post-office.	Experimenter.	Composition of the juice.			
					Total solids.	Sucrose.	Reducing sugar.	Purity coefficient.
		GEORGIA—continued.						
					Per cent.	*Per cent.*	*Per cent.*	
97	Nov. 25	Ware □			14.7	11.4	1.33	77.6
98	---do---	---do---			16.4	13.5	.87	82.3
100	---do---	---do---			16.2	13.6	1.05	83.9
99	---do---	---do---			16.1	13.2	.95	82.0
125	Dec. 4	---do---	Waycross	W. W. Sharpe	17.6	14.6	1.33	82.9
122	---do---	---do---	---do---	---do---	16.2	12.1	2.22	74.6
123	---do---	---do---	---do---	---do---	16.7	13.9	1.33	83.2
124	---do---	---do---	---do---	---do---	17.7	15.1	1.00	85.3
133	Jan. 3	---do---	---do---	---do---	17.1	13.3	----------	77.7
134	---do---	---do---	---do---	---do---	17.3	13.4	----------	77.5
34	Nov. 13	Washington □	Tennille	Mrs. A. Barge	17.0	14.4	1.04	84.7
35	---do---	---do---	---do---	J. J. Sherling	18.3	15.8	.91	86.3
36	---do---	---do---	---do---	J. T. Cook	18.9	16.6	.40	87.8
37	---do---	---do---	---do---	J. D. Franklin	18.1	15.6	.83	86.2
38	---do---	---do---	---do---	J. A. Smith	16.7	12.7	1.75	76.0
		State average (99 samples)			16.8	13.3	1.36	79.3
		SOUTH CAROLINA.						
39	Nov. 13	Hampton □	Yemassee	J. H. Stephens	13.2	13.2	1.28	79.5

NOTES ON THE ANALYSES.

The most striking characteristic of the analyses is found in the high average percentage of sucrose contained in these canes. Although the growing season in most places where these canes were produced is shorter than in Louisiana and the autumnal frosts come at an earlier date, yet it is seen in almost every instance that the percentage of pure sugar or sucrose in the juice of the canes is higher than the average percentage of the same substance in the canes of Louisiana. This difference must be due largely to the character of the soil. The rich alluvial soils of Louisiana produce a more vigorous growth, as a rule, with a tendency to slower maturity. At the time of harvest, therefore, the canes in Louisiana are greener and less mature than in Georgia, Alabama, and Florida.

The quantity of reducing sugar, or glucose, as it is commonly called—that is, sugars which do not crystallize readily and go to make up the bulk of the molasses in sugar factories—is quite low in most cases. The purities are also comparatively high.

It is evident that cane juices of the composition given would insure a fine yield of crystallized sugar if they were manufactured for sugar instead of sirup. Of course, the great objection to the establishment of a sugar industry in the region mentioned is the comparatively short manufacturing season. The canes are not mature until early in November, while killing frosts, except in Florida, are quite certain to occur before the end of November. These frosts may be at times of exceptional severity, as was the case in 1901, when the frost before the middle of November throughout the cane regions of Georgia was sufficient not only to kill the canes, but also in many cases to freeze them through and through. If in this region a season of three months for sugar making could be assured, it is evident that, in so far as the composition of the canes is concerned, there could be no doubt of the successful establishment of the sugar industry. In the climatic conditions, however, which obtain it would be evidently unwise to advise the establishment of such an industry, at least during the present low prices of sugar.

South Carolina, by reason of the small number of samples sent—viz, only one—should be excluded from the comparison of the data by States.

Of the other States, Georgia has sent by far the largest number of samples, and hence the average data from Georgia are more to be relied upon to show the general characteristics of the cane grown in that region than are the data from the other States.

In the 12 samples from Alabama it is seen that the average percentage of sucrose or pure sugar in the juice is 13.2, that of the reducing sugar 1.30, and the purity coefficient 78.8. This is somewhat lower than is desirable, the aim being to have a purity above 80.

Of the individual samples from Alabama several were of very high quality, especially some of those received from Henry County, viz, Nos. 13, 17, and 19. In these samples both the content of pure sugar and the purity are very high. An excellent sample was also received from Geneva County, viz, No. 22, in which the content of sucrose was 15.4 and the purity 84.6.

From Florida 24 samples were received, in which it is shown that the average content of sugar was 12.4, reducing sugar 1.26, and the average purity 79.7. As compared with Alabama the samples from Florida show a lower content of sugar, with a slightly higher purity. Many excellent individual samples were also received from Florida, and it is only because of a few which were exceptionally poor that the average of the State is so low.

Ninety-nine samples were received from the State of Georgia, representing practically every part of the State in which sugar cane is grown. The average data for Georgia show 13.3 per cent of sugar, 1.36 per cent of reducing sugar, and a purity of 79.3. A glance at the analytical data will show large numbers of samples of exceptionally fine quality, and the average is certainly surprising in the content of sucrose which it reveals. The coefficient of purity does not quite reach the desired standard of 80. It comes, however, very near reaching this standard, and falls below it by reason of the somewhat large percentage of reducing sugar which the Georgia canes have shown. Many of these canes were forwarded for analysis after the hard freeze referred to above, and hence the sucrose may, to some extent, have been inverted by fermentative processes after the frost. Nevertheless, taken as a whole, the data are entirely satisfactory. In so far as sirup making is concerned, indeed, a high content of reducing sugars is desirable, since these sugars tend to prevent the crystallization of the sucrose, which, when it occurs in commercial samples of sirups, unfits them to a certain extent for the market.

ARRANGEMENT OF A SIRUP FACTORY.

In the preceding pages it has been shown that the simplest apparatus can be used effectively for making sirup from sugar cane. In fact, some of the sirups of the finest flavor and most desirable qualities are produced with a simple mill, operated by a mule or horse, and with a single open kettle for evaporation. When working on a large scale, however, more extensive apparatus and appliances are required. It is evident that, in point of economy, the horse mill and open pan can not compete successfully with the heavier mills, defecating pans, steam evaporators, pumps for lifting sirups and juices, cranes for loading and unloading cane, and other mechanical appliances to save labor and facilitate rapidity of work.

The practical sirup maker can easily devise a factory arranged in a suitable way to secure his purpose. In order to make some suggestions which may be helpful in a case of this kind, I requested Mr. G. L. Spencer, of this Bureau, to prepare a brief outline sketch of a factory for making sirup, and as a result of this request the plans in figs. 1 and 2 have been prepared. It must be understood that the object of these sketches is not to furnish working details for building a sirup factory, but only to give in general an outlined plan of arrangement which will be suggestive to those who may be intending to build a factory with all the modern appliances.

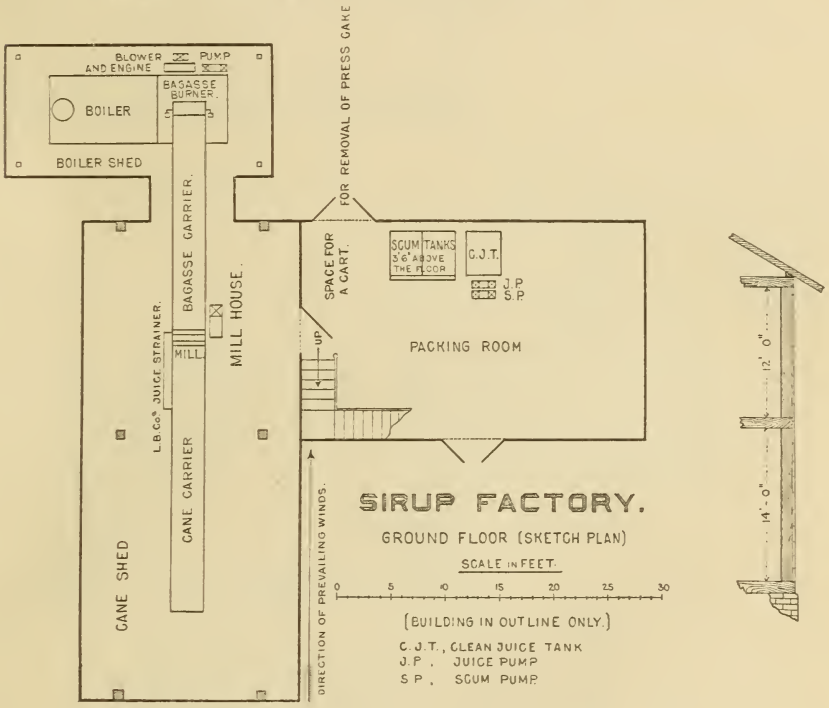


FIG. 1.—Sirup factory, ground floor: sketch plan.

PROBLEMS WHICH NEED FURTHER STUDY.

(1) The first problem encountered in the discussion of the study of table sirups is evidently a reexamination of the sirups now on the market to learn their character and determine the extent of the adulteration practiced therein. A study similar to this was made several years ago in this Bureau, and the results published in part 6 of Bulletin No. 13. Since that time, however, numerous new forms of adulteration have been invented and practiced, and the whole subject needs another investigation. To this end it will be necessary to purchase in the open market types of table sirups which are in use in

different parts of the country and subject them to careful chemical study.

The first object to be attained in an economic chemical study of this kind is to secure for the product of the sirup maker a fair and free market, in which the price of the article shall be regulated by its quality and by the law of supply and demand. It would be useless to study this problem from the chemical and technical side only, and in

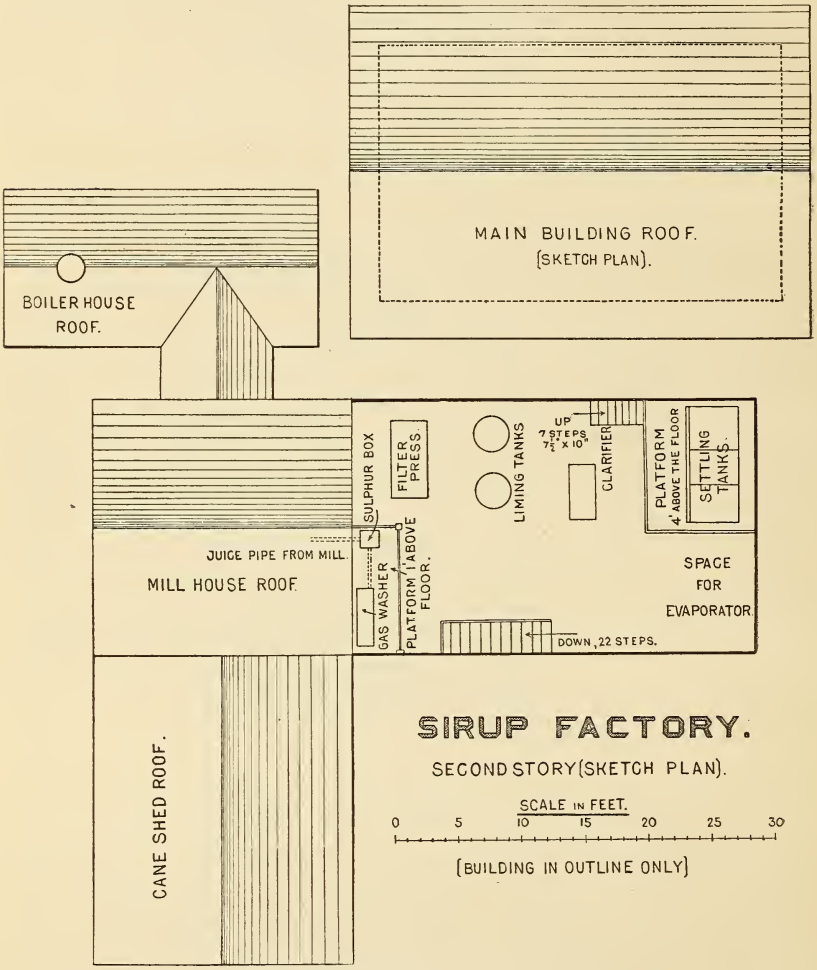


FIG. 2.—Sirup factory, second story; sketch plan.

the end to have a pure and wholesome product placed on the market and brought into ruinous competition with a cheaper and adulterated article. There can be no legal nor technical objection to the manufacture and sale of any kind of a table sirup, not injurious to health, made up of such ingredients as the manufacturer may desire to use

and the purchaser to consume. In other words, a market should be just as free to mixtures of glucose, melted sugar, and flavoring and coloring extracts, as to a pure sirup made directly from the cane or the maple tree. The only point to be kept in view is that these manufactured articles should be sold under their own names and labels and should not be allowed to imitate in name or label the qualities of the pure article. The maker of a pure table sirup from cane or other source has no right to demand that the market be closed to artificial mixtures or products intended for a similar purpose. On the other hand, the maker of these artificial products certainly has no right to utilize the name and label of the genuine article. Every class of business is perfectly legitimate if carried on in a legitimate manner, and the market should be open and free to all. A complete study of the character and extent of the adulteration of sirups is therefore the first step toward placing upon the market and securing the sale of the pure and unadulterated article.

(2) The agricultural problem, from the agricultural-chemical point of view, is also important. This problem has been discussed to a certain extent in this bulletin, and an extensive study of the character of the soil and the chemical properties of the product has been presented. It is evident from this examination that extensive fertilization must be practiced on soils of the kind indicated in order to secure large and remunerative crops. Only a thorough experimental trial of the fertilizers indicated by the analyses in various combinations and mixtures and applied to various kinds of soil will secure results which will enable the practical farmer to utilize the agricultural facilities which are placed at his disposal in the most economic and effective way. Numerous plot experiments in which fertilizing materials of different kinds are applied in definite quantities and under controlled conditions will be required to establish the general principles which will enable the farmer to use his fertilizers in the most advantageous manner. These experiments all require analyses of the fertilizers used, their measurement in definite quantities, and their application in a thoroughly scientific way.

(3) The third problem in connection with a study of this kind is the improvement of the milling processes in order to secure the largest possible expression of the juice of the canes. At the present time single mills of three rollers each are almost universally employed. There are no data which are sufficiently extensive to enable us to estimate the quantity of juice secured. It is evident, however, that the percentage of extraction is somewhat low, and probably accurate measurement would show that in many cases not over 60 per cent of the juice contained in the cane is expressed.

The bagasse coming from mills of this kind is entirely too wet to burn effectively. In fact, in the whole country in which sirups from sugar cane are manufactured fuel is so cheap there is little economic

importance in burning the bagasse. Since, however, the bagasse accumulates and must be removed, it is evident that if it can be burned and furnish the heat for manufacturing operations it would be the most economical way of disposing of it. The establishment, therefore, of milling processes which would leave the bagasse in a condition to be burned would not only increase the total output per ton of cane, but also diminish the expense of manufacture.

(4) The fourth problem which presents itself for investigation is the determination of the best methods of clarifying and purifying the juice previous to evaporation. This is a problem which has been worked out pretty thoroughly, and there is little left to study except mechanical and technical details. The principles of neutralizing the free acids present in the cane juices for the purpose of facilitating clarification must, however, be applied in a somewhat different manner in sirup manufacture than in making sugar. It is desirable in the case of sirups to leave the juice decidedly acid. This is necessary for two reasons. In the first place, the acid juices make a light-colored and more presentable looking sirup, and second, in the process of evaporation the free acids of the juices tend to invert certain quantities of the sucrose and thus render the finished product less liable to crystallization. To just what extent the neutralization of the natural acids can be carried to secure satisfactory clarification and yet leave sufficient acidity for the purposes mentioned above is a problem which demands careful study.

(5) The final problem which demands consideration in these studies is to secure a sirup of uniform character, both in color and consistence, and to put it in packages in such a way as to prevent fermentation during warm weather. When these two conditions are secured the marketable value of the sirup will be vastly increased. The first consideration would be probably to mix large quantities of the finished product and thus secure uniformity, as it would be found difficult, if not impossible, to manufacture at different times small quantities of sirup of a perfectly uniform color and consistence.

Not only should the sirup thus manufactured be preserved as indicated, but it also should be so treated as to prevent the possible crystallization of the sucrose. This, as indicated above, can be secured by inducing a certain amount of inversion during evaporation. The addition of antiseptics to sirup of this kind is to be in all cases discouraged as ill advised and possibly injurious to the consumer. Freedom from fermentation should be secured by packing the finished product in such a way as to exclude germs, or if germs be admitted during packing the final package should be sterilized before being sent to the market. Just what the methods will be for securing these desirable results can only be determined by actual experience.

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